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1. THE CANAIGRE OR TANNERS DOCK.
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THE CANAIGRE OR TANNERS DOCK.

By E. W. Hilgard, Director and Chemist.

The Canaigre or tanners dock (*Rumex hymenosepalus*) has of late attracted so much attention as a promising field crop and forms the subject of so many letters of inquiry addressed to this station, that it seems desirable to summarize for the benefit of the public the various results obtained and publications made in regard to it, here as well as elsewhere; in order to enable every one to form his own judgment in regard to the probable merits of the culture for this State. Thus far the best source of information on this plant is Bulletin No. 7 of the Arizona Experiment Station, at Tucson.

The canaigre plant, though recognizable as a dock by any attentive observer, differs from most of the common species in being of less height (rarely over two feet in this State) and more succulent; the stem rather brittle, the lance-shaped leaves smoother and of a lighter green than most others, quite smooth, and red-veined. The flowers and seeds are less abundant and larger than in our other docks, are borne on erect branches, and are suspended by longer and thinner, reddish-colored stalklets. The seed vessels are conspicuously winged and reddish, with a very small black seed. The tuberous roots resemble sweet potatoes or Dahlia roots; single ones weigh from six to fourteen ounces each, and from one to four are found with a single stalk.

The canaigre is indigenous to southern California as far north as the Kern valley, so far as known; it is more particularly at home, however, south of the Tehachipi mountains, in the sandy lands of the San Fernando and San Bernardino plains; also on the Gorgonio pass and on the border of the Colorado desert generally; also no doubt in the valleys of San Diego. Outside of California it is apparently most abundant in Arizona and southern New Mexico, and in northwestern Texas; it reaches to Utah and the Indian Territory. Its abundant occurrence in New Mexico led to the establishment of a factory for preparing the tannin extract for shipment instead of the root, and similar establishments were proposed for Arizona. But it has quickly become apparent that the supply of the wild plant would soon become exhausted, and that in order to place the industry upon a permanent basis it would be necessary to grow it as a regular crop. Now that the value of the root for the tanning of fine leathers has been fully established and a market is assured, the only remaining question is that of the best conditions for its cultivation, as to climate, soil, and mode of culture, to endure profitable returns.

As regards *climate*, it should be understood that in California the plant starts its growth from the root with the first rains, in October or November; reaches bloom about the end of January or first part of February, perfects its seed about April and dies down to the ground in May; varying according to the win-

ter temperature and the advent of spring warmth. It is not therefore to be expected that it will make a normal growth where the ground freezes in winter, although like some other culture plants it may be able to adapt itself to a different *régime* so long as the root is not frosted. We have not as yet any definite data as to what amount of winter cold will kill the root.

As to *soil*, the presumption is that, like other root crops, it will do best in light soils, which it seems to occupy naturally by preference. Yet it has made a good normal growth in the heavy black adobe of the Economic Garden at this station, which however has, of course, been kept well tilled. It appears therefore to be quite adaptable to a variety of soils; the New Mexico station reports "adobe soil" as its preferred ground, but the term is evidently used there in a different sense, as designating the loams of the character actually used for building adobe houses; a use for which the average adobe of California would be inapplicable.

Propagation.—The easiest way to obtain a stand of the canaigre is to plant the smaller roots obtained in harvesting the crop. These develop rapidly and according to the observations made at the New Mexico station will, when irrigated, quadruple their weight in one season; they will also in that case produce seed abundantly. One marked peculiarity of the roots, remarked upon by all reports, is that when cut, the upper portion (the one having the root crown) will reconstruct its lower part by new growth which differs markedly from the older by its smoothness.

Propagation by seed seems to occur quite rarely in Arizona and New Mexico, as well as in California south of the Tehachipi range. But with more abundant moisture, as in the "Weed-patch" of the Kern valley (an ancient channel still receiving some seepage) and at this station when early rains occur, the fallen seeds sprout abundantly; and we will the coming season be enabled to ascertain what advantage there may be in propagating by seed instead of devoting a portion of the root crop to replanting. The seed must be sown quite shallow and lightly covered, when the ground is moist.

When irrigated the roots will stand close planting, say nine or ten inches apart in rows thirty inches apart, as in the case of sugar beets. Since the roots are on the average somewhat smaller than sugar beets, the average crop will be somewhat less in weight.

Canaigre roots will sometimes remain in the ground during several successive dry years without injury, growing as soon as the needful moisture comes. This indicates the mode of keeping the roots for seed, viz.: in dry sand or loam, in a dry place. When kept in piles for any length of time, the canaigre root heats and spoils even quicker than the sweet potato.

Cultivation will, it must be presumed, not differ materially from that of the sugar beet, except that there will be no thin-

ning needed; and as in the case of the latter, only a few cultivations will be required to subdue weeds and to maintain good tilth in the rainless summer climates in which it is at home. The Arizona station prescribes that "to secure the largest yield the planting should be done before the first of October (in that climate) and the soil moistened and plowed; then the roots dropped and covered with a potato planter adjusted to suit the case. The crop should be irrigated from four to six times and some implement of the two-horse cultivator style run through the rows after each irrigation."

The amount of irrigation that should be given will of course vary according to the kind of soil and the natural moisture. As it seems that too much water depresses the tannin-percentage (see below), while increasing the weight of the crop, there is evidently a certain measure that cannot be profitably exceeded, but which must be established by experiment. At this station, with an average rainfall of 23 inches during the winter, irrigation is certainly not called for.

Harvesting can be done as in the case of beets, by means of a "digger" such as is used for potatoes and (in a modified form) for the sugar beet. A crop of ten tons per acre from roots planted as indicated above and properly cultivated for one season, is probably a fair average expectation.

But it is not necessary to harvest the root at any particular time, since it not only does not deteriorate by remaining in the ground but actually increases its tannin-percentage about the time the buds for the second year's growth begin to move; as has been shown at the Arizona station. In fact the tannin appears to increase to a maximum at the end of the second season, after which it seems to remain constant; at least we have never found a higher percentage in roots older than two years, than in the two-year-old. As the roots do not die or decay, it is optional with the farmer when to dig them. At this station, when a clump that had grown from a single root was dug up after remaining undisturbed for eight years, not a decayed root was found and the whole weighed 13 pounds. The older roots are much darker in color and have a rougher surface than new roots, which are as smooth as sweet potatoes.

The canaigre thus differs from almost every other crop in that its harvest can wait for the convenience of the farmer, within wide limits. It is not certainly known as yet whether the root increases in weight after the second year; our impression is that the increase is slight if any, and that it will not be found best to defer harvesting after the second year. But we have found that there is no material difference in the tannin contents of the full-grown root whether the plant is resting, blooming or seeding.

Marketing.—As has been stated above, the canaigre root, while an excellent keeper when kept very dry, spoils readily when

kept in mass. It cannot therefore be shipped green to any great distance, but must for distance shipments be either dried or converted into extract.

Drying is costly and laborious, and after all of somewhat uncertain result on the large scale. Tannin is a very easily decomposable substance; drying at a high temperature will injure it as well as when, at too low a temperature, the drying progresses too slowly and permits fermentation to start up. Even small roots cannot be dried whole without serious deterioration; it is absolutely necessary to slice them, very much as beets are sliced for sugar-making. But when machinery is once procured for slicing, it seems better to go a step farther and end all fear of deterioration by preparing the *extract*, which will keep indefinitely.

The cost of a factory plant for preparing the extract need not be large, but it must be managed by competent hands.

According to the data obtained by the Arizona station, agreeing well with the averages obtained by us, three tons of green roots will make one ton of dried, or one-half ton of extract; or, six tons of green root will yield one ton of extract, averaging from 60 to 65 per cent. of tannin, and, therefore, very well capable of shipment to a distance, so far as value is concerned.

Structure and chemical composition of the root.—As the canaigre root varies in its outward aspect, so it also differs quite obviously in its internal appearance. Old roots are darker-colored than young ones, both outside and inside; the latter point seems also to be influenced by differences in soil and cultivation.

The fresh root shows on a cut surface irregular orange or lemon-yellow blotches and streaks, sometimes covering the greater part of the section almost uniformly. On exposure to the air the color rapidly darkens into brownish-red, which is also the color of the extract as a whole. Microscopic examination shows that the coloring substance (aporetin?) is contained in separate cells almost free from starch grains, while the uncolored tissue is full of starch. The tannin appears to be very uniformly distributed throughout, in solution in the sap; but in the case of large roots appears to be most abundant near the axis or center line, contrary to what occurs in the case of sugar in the beet.

The tannin-content of the fresh and dried root from different localities, of different ages, etc., as heretofore determined at this station, are given in the subjoined table; for the sake of comparison, the tannin percentages found in other materials available in this State are also given.*

*The tannin determinations given here have been made by the permaganate method, but have been repeatedly checked by the gelatine (or hide-scrap) method, with but trifling differences in the results. These therefore represent fairly what hides will take up from the root or root extract.

	Material.	Locality.	Sender or Grower	Water, per cent.		Tannin, per cent.		
				Fresh.	Air dried.	Fresh.	Air dried.	Dried at 100° c.
1	[1] Canaigre (Root of *Rumex hymenosepalus*)	Northwestern Texas		*68.07	11.17	8.51	23.45	26.30
2	Canaigre	San Gorgonio Pass	Dr. C. C. Parry.	*75.00	11.40	9.60	34.20	38.40
3	Canaigre, roots sliced and dried						14.97	16.90
4	Canaigre, roots dried whole						5.40	6.09
5	Canaigre, roots with little coloring matter	Gathered April 10, 1889. Experimental Garden, Berkeley.				5.91	30.80	34.76
6	Canaigre, roots with large amount coloring matter.					5.97	31.13	35.14
7	Canaigre, outside sections of root					5.60	27.64	31.20
8	Canaigre, inside sections of root			83.00	11.40	7.79	40.57	45.80
9	Canaigre root, small							
10	Canaigre root, large					7.10	37.03	41.79
11	Canaigre root	Gathered May20,'89				6.54	34.11	38.51
						5.80	30.21	34.12
12	"Red Dock" (wild)	Weed-patch, Kern Co.	L. H. Filcher.		12.50		25.30	29.00
13	"White Red Dock" (wild)	South Fork Kern River.	A. B. Leckenby.	*61.40	10.50	7.50	17.43	20.30
14	Canaigre (one year old, grown with irrigation)	Bakersfield, Kern Co	A. B. Leckenby.	*74.80	11.10	4.35	15.35	17.80
15	"Red red Dock" (wild; on moist ground?)	Weed-patch, Kern Co.	A. B. Leckenby.	*74.20	12.66	9.00	30.70	35.10
16	"White Dock" (*Rumex Berlandieri?*	Weed-patch, Kern Co.	L. H. Filcher.	48.88		0.00	00.00	00.00
	Other Tanning Materials.							
17	Black Wattle (*Acacia decurrens*) Bark	Experimental Garden, Berkeley		45.70	14.85	26.4	41.40	48.60
18	Silver Wattle (*Acacia dealbata* var. *mollisima*) Bark.			47.99	20.49	13.1	19.70	24.80
19	Golden Wattle (*Acacia pycnantha*) Bark			41.10	11.19	27.6	41.60	46.80
20	European Tanner's Sumac (*Rhus coriaria*) Leaves				10.20		16.80	18.70
21	California Tall Sumac (*Rhus integrifolia*) Leaves	San Fernando plain, Los Angeles Co					11.70	
22	California Tan-bark oak (*Quercus densiflora*)						12.00	
23	[2] Oak (*Quercus pedunculata*) Bark						10.50	
24	[2] Hemlock (*Abies canadensis*) Bark						12.00	

* Partially dried in transmission. 1 Analysis taken from Report Sec. Agriculture, 1878. 2 Analyses taken from Allen's Commercial Organic Analysis, VIII.

The first analysis here given was published in the report of the U. S. Dep't of Agriculture for 1878 and refers to roots from northwestern Texas. It will be noted that the tannin percentage there given (26.4 on the average) is the lowest of all the results obtained from wild roots. The Arizona Station gives as the average of wild roots from that territory 30.5% of tannin while the average of the wild roots from California is seen to be 35.85, or 5.35% higher. Whether this is due to climatic or soil differences remains to be determined. The fact that large roots from the Gorgonio Pass and from the Berkeley Economic Garden both yielded the maximum percentage (38.5), while the soils are respectively at the opposite extremes of sandiness and clayeyness, would seem to indicate climatic factors as the more probable cause of difference. At all events, it appears clearly that the California-grown root is likely to be superior rather than inferior to that grown farther south.

As regards the relation of tannin-contents to *color*, analyses 4, 5, 11, 12 and 14 furnish some interesting indications. It appears that in Kern county the canaigre is known as "red dock," probably more from its red leafstalks and veins than because of the color of the root. There is a variation in the color which is expressed by the popular names of "white red" and "red red" dock, while there is also a kind called "white dock." The latter, as the table shows is a different species and contains only traces of tannin; the "white red" has only a little over 20%, the "red" (No. 11) 29%, the "red red" 35%. It is thus evident that in the case of the canaigre as well as in that of other culture plants, there is a considerable variation in the quality of different varieties; and it seems that the deeper the tint of the foliage (and root) the greater the tannin-yield is likely to be. Doubtless in the future we shall be able to improve the canaigre in this respect as the sugar beet has been. But it is also clear that the extent of moisture and irrigation has a very great effect in this direction; since we see that the well-irrigated plant from the experimental field of the Kern Co. Land Company near Bakersfield yields only 17.8%, or about half as much as the best wild plant.

Analyses 1, 2 and 3 show plainly the effects of drying in various ways. No. 1 was rapidly dried by steam heat after cutting into very thin slices; No. 2 was cut more thickly and placed in a drier on a tray, as might be done on the large scale; No. 3 was dried whole at a gentle heat. It will be noted that while the first contained an unusually high percentage, the second was reduced to less than half, and in the third, five-sixths of the tannin was destroyed by the process.

Comparing the canaigre with other tanning materials given in the table, it will be seen that the bark of the black wattle and golden wattle exceed the root in tannin contents. The question then arises whether, supposing the two materials to be of equal

quality for tanning purposes, it will be more profitable to grow canaigre than the wattles. An approximate comparative estimate for the crops will therefore be of interest.

Here the time element comes in as an essential factor. It takes eight or ten years to mature a wattle plantation; the yield of bark per acre is, for the first eight years (for the black wattle), estimated at about twelve tons, besides possibly 100 cords of wood, available for firewood. This estimate is based upon the planting of 400 trees per acre; close planting being desirable in order to secure long trunks. The bark is worth about $25 per ton in Australia. At the end of eight years twenty acres will yield 240 tons of such bark (value $6,000), plus 2,000 cords of trunk wood, which would barely bring one dollar per cord in this country. Therefore $8,000 represents the gross returns for the twenty acres as against about $2,050 of cash outlay plus rent of land, interest, wear and tear, etc. The clearing of the land for replanting would cost from $40 to $50 per acre, so that $800 to $1,000 must be added to the above estimate of cost; leaving the net returns for the eight years about $5,000.

On the other hand we would have in the case of canaigre, estimating on the cost of the cultivation of sugar beets, and allowing for the differences in the operations required, about $3,000 for the eight years, plus again the rent of land, interest and wear and tear. In return for this, at the rate of ten tons of roots per acre, there would be obtained 1,600 tons of fresh roots worth $8,000 upon the basis of the price of beets only (viz.: $5 per ton). According to the prices as above estimated the outcome of the eight years' culture would be very nearly the same for black wattle and canaigre. But the returns from the latter, unlike the former, would bear interest during the eight years; and the wide climatic range of the canaigre renders it much more widely available.

This presupposes that the tannin of both plants will in commerce bring about the same prices. But it is well known that the acacia tannin is not available for the tanning of fine leathers, for the reason that it tends to render them somewhat brittle. But if, as we are now informed, the tannin of canaigre (rheo-tannin) is well adapted to *all* purposes, including the finest leathers, it will go far towards throwing the balance still farther on the side of the root as against the trees, particularly where the price of labor and capital is high.

ASH COMPOSITION AND NITROGEN CONTENTS OF THE CANAIGRE ROOT.

In its draft upon the soil ingredients, the canaigre differs from the beet and most other root crops in drawing much less heavily on potash, but more heavily on magnesia, and on phosphoric and sulphuric acids. The following table illustrates these points. The ash analysis of the root, grown at this sta-

tion, was made by Mr. P. W. Tomkins, a student in the agricultural laboratory. That of the sugar beet, placed alongside, is an average from European data:

Ash Composition of Canaigre Root.

	Canaigre.	Sugar Beet.
Silica (SiO_2)	3.89	3.50
Potash (K_2O)	28.74	49.40
Soda (Na_2O)	2.47	9.60
Lime (CaO)	8.16	6.30
Magnesia (MgO)	16.93	8.90
Br. ox. manganese (Mn_3O_4)	.98	.....
Per-oxide of iron and alumina	2.45	1.10
Phosphoric acid (P_2O_5)	18.19	14.30
Sulphuric acid (SO_3)	13.16	4.70
Chlorine	6.43	2.60
	101.40	100.40
Excess of oxygen due to chlorine	1.40	.57
Total	100.00	99.83
Percentage of pure ash in dry root	4.48	4.35
Percentage of crude ash in dry root	4.79	5.44
Percentage of carbonic acid in crude ash	5.20	20.00
Percentage of total nitrogen in dry root	1.93	.87

A partial analysis reported from the Arizona station, while confirming the greater demand for phosphoric acid by canaigre as compared with the sugar beet, assigns to the former twice as much potash as to the latter, and does not mention either soda or magnesia. While such differences are not unexampled, these data can hardly be accepted as proving them in this case. Roughly speaking, we are probably justified in assuming that for equal weights of crop the cost of replacing the mineral soil ingredients by the purchase of fertilizers when necessary, will be about the same for both crops; while as regards nitrogen, our determination shows that the canaigre draws nearly twice as heavily as the beet, so that a crop of ten tons of fresh roots will take out of the soil nearly 100 pounds of nitrogen per acre. In regular culture, it should, therefore, probably be alternated with leguminous crops, that enrich the soil in nitrogen.

AUSTRALIAN SALT BUSH.

Atriplex semibaccatum, a forage plant for alkali soils.

By M. E. Jaffa, Ph. B., Instructor in charge of Agricultural Laboratory.

According to our observation this plant, originally obtained from Baron v. Mueller of Melbourne, strongly commends itself as a forage plant for alkali lands in the San Joaquin valley and elsewhere in California. It seems to be readily eaten by stock and can be successfully grown on alkali lands which will not sustain any other crop. As the name implies, the plant is indigenous to Australia; and on page 59 of Baron Ferd. von Mueller's "Select Extra-tropical Plants," is found the following statement:

"*Atriplex semibaccatum*, R. Brown.—Extra-tropic Australia—a perennial herb, very much liked by sheep (R. H. Andrews), thus considered among the best of saline herbage of the salt bush country. Mr. Will Farrer pronounces this herb as wonderful for its productiveness and its drought-resisting power."

Unlike most of the other salt bushes, this plant has a prostrate habit, covering the ground with a green cushion 8-10 inches thick. Single plants form wheel-shaped masses, with small, narrow leaves ($\frac{1}{2}$ to $\frac{3}{4}$ long by $\frac{1}{8}$ to $\frac{3}{16}$ inch wide) thickly set on numerous small, slender branches; flowers inconspicuous but fruit (heart-shaped and about $\frac{1}{10}$ inch long) of a brownish-red tint, very abundant. Plant perennial and when cut soon reproducing itself from the same root.

At the Experiment Station near Tulare, the herb, or bush, has been planted with excellent results in some of the worst alkali spots of the station grounds; single plants having reached a diameter of sixteen feet in one season. The yield of a full cut is about twenty tons of green material, or, calculating on a basis of seventy-five per cent. water, five tons of dry matter per acre. According to the data given by the foreman, Mr. Forrer, a long season would permit of two such cuts.

Propagation.—The plant grows very readily from seed, which is produced in abundance and which, as foreman Forrer states, should not be covered when fresh, being liable to rot; but should be dropped on the surface of the soil before a rain, and when warm weather comes it will germinate and take care of itself. When young plants are transplanted in a dry time they need watering two or three times.

In feeding the salt bush it has been used in conjunction with hay, about $7\frac{1}{2}$ pounds of green salt bush to $2\frac{1}{2}$ pounds of hay at one feed, or in the ratio of three to one. Sheep and hogs eat it green without the least trouble; horses and cattle soon get used to it if fed mixed with other feed at first. They never need any salting.

Composition.—A chemical investigation of the fresh plant as grown at Tulare gave the following results; analyses of other fodders are given for comparison:

TABLE I. PROXIMATE ANALYSIS OF THE AUSTRALIAN SALT BUSH COMPARED WITH SOME GREEN FODDERS:

	Salt Bush.	Alfalfa.	Flat Pea.	Oat Fodder.
Water	78.03	74.95	63.48	62.20
Organic	17.39	23.38	33.34	35.30
Mineral Matter (Ash)	4.58	1.67	3.18	2.50
Total	100.00	100.00	100.00	100.00

It is thus seen that of the foods here represented, the salt bush contains the least organic matter and the most ash and water; the ash being nearly three times that found in alfalfa, about one and a half that given for the flat pea, and not far from twice the mineral contents of the oat fodder.

The moisture percentage in the Australian plant and the alfalfa are quite close and both considerably higher than those found in the flat pea (*Lathyrus sylvestris*) and the oat fodder.

In Table II is given the detailed analysis of the salt bush, showing its food value.

TABLE II. FOOD VALUE OF SALT BUSH.

	Fresh.	Air-dried.	Water-free.
Moisture	78.03	7.05	.....
Albuminoids	2.75	11.64	12.53
Nitrogen-free Extract	10.41	44.05	47.39
Fat	.48	2.01	2.16
Cellulose (fiber)	3.75	15.88	17.08
Ash	4.58	19.37	20.84
Total	100.00	100.00	100.00

The above analyses prove that this fodder is one of considerable merit; containing high percentages of that very important constituent, the albuminoids. The contents in nitrogen-free extract (starch, sugar, gums, etc.), are about an average, while the fat is somewhat low. The mineral matter represented by the ash percentage, as before stated, is exceedingly high, being nearly one-fifth the total weight of the air-dried plant.

A comparison with some typical fodders will more strongly bring out the value and importance of the Australian salt bush as a cattle food. Table III below gives these data.

For explanations of all the terms used in this discussion see Bulletin No. 100 of this station.

TABLE III. SHOWING COMPOSITION OF THE SALT BUSH AND SOME OTHER FODDERS.

	AIR-DRIED SUBSTANCE.											
	Percentage Composition.						Am't digestible in 100 lbs.				Potential Energy in 1 lb (Calories).....	Nutritive Ratio.....
	Moisture.....	Pure Ash.....	Crude Protein.....	Crude Fiber.	Nitrogen-free Extract.....	Crude Fat...	Crude Protein.....	Crude Fat.....	Crude Fiber..	Nitrogen-free Extract.....		
Australian Salt Bush.....	7.05	19.37	11.64	15.88	44 05	2.01	8.75	1.21	8.58	29.63	925	1:4.5
Alfalfa.....	11.92	5.89	14.10	21.55	44.27	2.57	10.58	1.23	9.77	30.10	990	1:4.1
Lath. Sylvestris (Flat Pea).....	10.00	7.83	20.16	24.05	33.94	4.02	15.32	2.41	13.94	22.06	1070	1:2.7
Oat Hay (Cal.).....	10.38	6.75	8.31	23.85	47.91	2.80	4.74	1.34	13.83	29.70	954	1:9.9
Barley Hay (Eastern)..... ...	10.25	4.44	9.21	26.14	47.49	2.47	5.25	1.19	15.16	29.44	979	1:9.1

An inspection of the figures indicating the *protein contents* of the different foods show that the salt bush, containing 11.64 per cent., exceeds in this respect both the oat, with 8.31, and the barley hay, with 9.21 per cent. Alfalfa, showing 14.10 per cent., is somewhat richer in this respect than is the salt bush, while the flat pea contains nearly double the quantity so found, as indicated by the respective figures, 20.16 and 11.64.

The *fat* percentage, 2.01, in the salt bush is about four-fifths of that found in the other materials, with the exception of the flat pea, which has 4.02 per cent., just double the above figure.

The figure for *nitrogen-free extract*, 40-05, does not differ materially except in the case of the flat pea, where it is only about three-fourths of this amount.

Crude fiber in the salt bush is present in much smaller amount (15.88 per cent.) than it is in the other fodders, the average for them being 23.89; since woody fiber is the least digestible of any part of a fodder, this is rather an advantage than otherwise.

When the amounts of *digestible nutrients* (protein, fat, starch, sugar, gums, etc.) in each food are compared, the showing for the salt bush is still more promising. The nutritive ratio (the proportion between the digestible nitrogenous and non-nitrogenous parts of the food) for alfalfa and the salt bush are almost identical and ahead of both the oat and barley hay, as is seen when comparing the figures 1:4 and 1:9. The flat pea being exceptionally rich in protein, shows naturally an excellcellent nutritive ratio, 1:2.7. The potential energy is slightly more in the case of the other foods than that given for the salt bush, owing to its high ash percentage.

Composition of the Ash.—The large proportion of ash in the salt bush and the fact of the plant yielding such excellent results in some of the worst alkali spots, rendered desirable a complete examination of the ash, in order to ascertain the character of the mineral ingredients taken from the soil. The

results of the analysis, made by Mr. P. W. Tompkins, a student in the Agricultural Laboratory, are given below:

Silica (SiO_2)	16.24
Potash (K_2O)	11.42
Soda (Na_2O)	35.39
Lime (CaO)	5.79
Magnesia MgO	3.23
Per-Oxide of Iron (Fe_2O_3)	1.38
Alumina (Al_2O_3)	1.95
Br. Oxide of Manganese (Mn_3O_4)	.22
Phosphoric Acid (P_2O_5)	2.80
Sulphuric Acid (SO_3)	2.64
Chlorine (Cl)	24.33
	105.35
Excess of O due to Cl	5.35
Total	100.00
Per cent. of pure ash in air-dried substance	19.37

From the data here presented we see that for 100 pounds of air-dried material there are 19.37 pounds pure ash. Assuming the water in the fresh substance at about 75 per cent., every 100 of dry matter corresponds to 400 green. Each ton of green stuff is equivalent to 500 pounds of strictly dry material or 550 pounds of air-dried matter, containing about 110 pounds of mineral ingredients. Of this extraordinary amount of ash, nearly 40 per cent., or 44 pounds, is common salt, and about 15 per cent., or 17 pounds more is soda in other combinations; in the crude ash mainly in the form of carbonate of soda. The amounts of potash, lime and phosphoric acid are relatively small, thus rendering the salt bush excellent for "desalting," or freeing the soil from objectionable sodium compounds.

Fertilizing value of the ash.—In the ash from a ton of air-dried plant there are nearly 14 lbs. of potash, and 3.5 lbs. phosphoric acid available as plant food; or, estimating about 6 tons to the acre, 84 lbs. potash and 21 lbs. of phosphoric acid. But as potash exists in more than sufficient quantity in most of the valley soils of the State, it is only the phosphoric acid that is to be considered when regarding the fertilizing value of the ash. The advantage which would accrue to the soil by the addition of that amount of phosphoric acid would be much more than offset by the large amount of alkali salts, chief among which would be the "black alkali," or carbonate of soda, and the common salt, accompanying the phosphoric acid.

In the following table is given the analysis of the ash of the salt bush and that of some other plants, for the purpose of showing the comparative amounts of mineral ingredients withdrawn from the soil by them:

TABLE IV. SHOWING ASH COMPOSITION OF THE SALT BUSH IN COMPARISON WITH SOME OTHER PLANTS.

	Australian Salt Bush.	Greasewood, Kern Co..	Alfalfa, Eastern ..	Timothy Hay, Eastern..
Silica	*16.24	11.81	9.38	35.60
Potash	11.42	18.53	23.45	28.80
Soda	35.39	39.45	1.56	2.70
Lime	5.75	1.36	44.30	9.30
Magnesia	3.25	1.09	4.68	3.60
Br. Ox. Manganese	.22	.....	.....	.....
Peroxid Iron and Alumina	3.33	7.06	.....	.....
Phosphoric Acid	2.80	3.51	8.34	10.80
Sulphuric Acid	2.64	4.93	5.73	3.90
Chlorine	24.33	15.30	3.12	5.00
	105.35	103.04	100.56	99.70
Less excess of O. due to Cl	5.35	3.25	.68	.....
Total	100.00	99.79	99.88	.....
Percentage of Ash in air-dried plant	19.37	12.03	5.89	6.15

It is thus seen that the ash of the salt bush approaches more nearly to the composition of the ash of the greasewood than to that of either the alfalfa or the timothy. The percentages of potash and phosphoric acid in the ash of the salt bush are both less than in any of the other plants.

But although the *percentages* of these two vital ingredients are somewhat low, the actual *amounts* contained in the ash from a single crop of the salt bush are far in excess of those found for an ordinary crop of hay.

The lime in the case of the salt bush is about four times that found in the greasewood, but a little less than one-seventh of the amount noted for alfalfa and about two-thirds the quantity present in timothy hay. The most striking feature of the salt bush as compared with the other plants, is the excessive amount of chlorine, as shown by the figure 24.33 as against 15.30 for greasewood, and 3.12 per cent. and 5.00 for alfalfa and timothy, respectively. The corresponding amounts of sodium chloride (common salt) are 38.93, 24.48, 4.99 and 8.00.

While it is true that the percentages of potash and phosphoric acid are less in the ash of the salt bush than in that of the other plants, when calculated on the *same amount of ash*, yet the percentage of ash being so much greater in the salt bush, there will be withdrawn from the soil more potash by a ton of salt bush than by the same weight of the other cultures. Table V illustrates this point.

* About one-half of the silica is soluble in carbonate of soda solution.

TABLE V. QUANTITIES OF SOIL INGREDIENTS WITHDRAWN BY VARIOUS PLANTS (Air Dried).

	Total Ash lbs	Potash, lbs.	Phos Acid, lbs.	Lime, lbs.	Nitrogen, lbs
Salt Bush–In 1,000 lbs.	193.70	21.30	5.93	11.14	18.60
Crop of 10,000 lbs.	1,937.00	213.00	59.30	111.40	186.00
Greasewood–In 1,000 lbs.	120.30	22.29	4.22	1.64	.....
Crop of 10,000 lbs.	1,203.00	222.90	42.20	16.40	.....
Alfalfa–In 1,000 lbs.	65.00	13.49	6.43	22.86	*22.50
Crop of 12,000 lbs.	780.00	161.88	77.16	274.32	225.00
Wheat (whole plant)–In 1,000 lbs	51.26	9.15	4.13	2.30	8.75
Crop of 5,000 lbs.	256.30	45.75	20.65	11.50	43.75
Timothy Hay–In 1,000 lbs.	61.50	17.71	6.64	5.72	15.40
Crop of 5,000 lbs.	307.50	88.55	33.20	28.60	77.00

The *total ash* of a crop of salt bush, as indicated by the percentage, is more than three times that contained in one of timothy, two and a half times that removed by a crop of alfalfa, and about one and a half times greater than the figure obtained for greasewood.

Potash.—The amount of potash removed from the soil by a crop of salt bush does not differ materially from that reported for greasewood; but is *greatly* in excess of the quantity withdrawn by alfalfa, more than twice that required for timothy, and nearly five times the amount found in wheat hay.

Phosphoric acid.—The draft upon the soil by phosphoric acid is greatest in the case of alfalfa and least in wheat hay. The amount found in the salt bush, 59 pounds, being nearly three times that given for wheat hay, still is only about three-fourths the weight of phosphoric acid required for a crop of alfalfa.

Lime.—With reference to lime it is seen that a crop of alfalfa carries away more of this ingredient than do all the remaining plants here presented, as shown by the figures 274.32 for alfalfa and only 167.90 for the other crops combined.

Nitrogen.—The highest figure for nitrogen, 225.00, is reported for alfalfa; the salt bush requiring about four-fifths of this quantity. We therefore see that while the salt bush removes from the soil an enormous amount of ash, it does not draw upon the vital ingredients to a corresponding extent.

Amount of alkali salts removed from the soil by a crop of salt bush.—It is of interest to know just how much of the injurious salts of alkali soils are extracted, per acre, by an average crop of the salt bush. As before stated this plant is grown on some of the worst spots of " black alkali " at Tulare station.

An analysis of the alkali salts of one of these spots gave the following results:

	Percentage Composition.	Pounds per 100 of Soil.
Potassium sulphate	6.13	.111
Sodium sulphate	35.97	.651
Sodium chlorid	26.79	.485
Sodium carbonate	28.12	.509
Sodium nitrate	2.99	.054
Total	100.00	1.810

*According to latest analysis of the California fodder.

This analysis shows that the chief ingredient of the alkali is sodium sulphate or Glauber's salt; still, sodium carbonate ("black alkali") forms nearly 30 per cent. of the alkali salts and more than one-half of one per cent. of the soil.

In column I, of Table VI, below, are given the amounts, in pounds per acre, of alkali salts in the crude ash of a crop of the salt bush, estimating the yield at five tons per acre. In column II, the number of pounds of the salts as they occur in the soil; assuming an acre one foot deep to weigh four million pounds. Column III expresses the percentage of the total quantity in the soil, which is extracted by the salt bush:

Table VI.

	I. Alkali Salts in crop of Salt Bush. Pounds per acre.	II. Alkali Salts in Soil. Pounds per acre.	III. Percentage of Total Salts extracted by Salt Bush.
Potassium Sulphate	111.48	4440	2.51
Sodium Chlorid	777.59	26000	2.99
Sodium Carbonate	471.10	20360	2.31
Total	1360.17	50800	Average. 2.60
Total Sodium Salts	1218.68	46360	2.63

From this showing it will be noted that sodium carbonate and sodium chlorid, the two most injurious of alkali salts, are removed from the soil in no inconsiderable quantities by a single crop of the salt bush; and while it would require many years of such cropping to render such a soil, containing nearly one and three-quarters per cent. of alkali salts, fit for other cultures, yet on soils where the percentage of alkali is near the limit of injury, a few crops of the salt bush would, in all probability, bring it below the danger point.

Summary of practical advantages of the salt bush.

1. It can be grown successfully on arid and alkali lands.

2. Soils where the percentages of alkali are near the limit of tolerance can no doubt be sensibly relieved by planting the salt bush, and permanently removing each cutting from the land.

3. The yield is very large, about the same as that of alfalfa and the flat pea; but nearly, if not quite double that of either oat, barley or wheat hay.

4. The composition is, aside from the ash, such as to make it an excellent food for stock; it seems to be readily eaten by them.

The question still to be settled is whether the large amount of saline ingredients will be harmless to all kinds of stock, e. g. milch cows. Assuredly no salting will be called; and if no purgative effects are noted, no other disadvantages need be apprehended.